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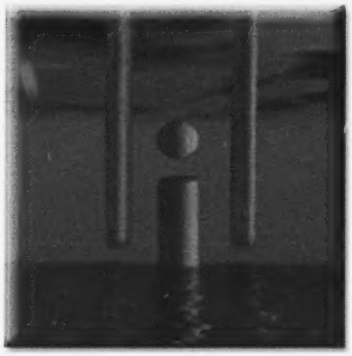
# Experimental Measures of Output and Productivity in the Canadian Hospital Sector, 2002 to 2010



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April 2014

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| | |
|---|---|
| . | not available for any reference period |
| .. | not available for a specific reference period |
| ... | not applicable |
| 0 | true zero or a value rounded to zero |
| $0^s$ | value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded |
| $^p$ | preliminary |
| $^r$ | revised |
| x | suppressed to meet the confidentiality requirements of the *Statistics Act* |
| $^E$ | use with caution |
| F | too unreliable to be published |
| * | significantly different from reference category ($p < 0.05$) |

# Experimental Measures of Output and Productivity in the Canadian Hospital Sector, 2002 to 2010

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**The Canadian Productivity Review**

The Canadian Productivity Review is a series of applied studies that address issues involving the measurement, explanation, and improvement of productivity. Themes covered in the review include, but are not limited to, economic performance, capital formation, labour, prices, environment, trade, and efficiency at both national and provincial levels. The Review publishes empirical research, at different levels of aggregation, based on growth accounting, econometrics, index numbers and mathematical programming. The empirical research illustrates the application of theory and techniques to relevant public policy issues.

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# Table of Contents

**Abstract** ..... **5**

**Executive summary** ..... **6**

**1 Introduction** ..... **9**

**2 Methodology** ..... **10**

**3 Data** ..... **13**

3.1 Total hospital expenditures ..... 14

3.2 Inpatients ..... 14

3.3 Outpatients ..... 15

**4 Direct output measures** ..... **17**

4.1 Cost-weighted activity index, inpatient and outpatient cases assigned to different case types ..... 18

4.2 Cost-weighted activity index, inpatient and outpatient cases assigned to same case types ..... 19

4.3 Cost-weighted activity index from a counterfactual ..... 20

4.4 Productivity growth of the hospital sector ..... 21

**5 Conclusion** ..... **24**

**References** ..... **26**

## Abstract

This paper constructs a direct output measure of the hospital sector in Canada. The volume index of the output of the hospital sector is estimated from aggregating the number of inpatient cases and outpatient cases using their cost share as weights. It also examines two potential sources of bias in this cost-weighted volume index: substitution bias and aggregation bias. The analysis reveals a large substitution bias in the volume index when inpatient treatment and outpatient treatment of the same medical disease/condition are aggregated using their respective unit costs as weights. The substitution bias essentially captures quality improvements associated with the shift away from inpatient treatment toward outpatient treatment. The volume index of the hospital sector output corrected for substitution bias increased 4.3% annually during the 2002-to-2010 period. Labour productivity based on the direct output measure is estimated to have increased 2.6% annually over the period.

# Executive summary

Recent discussions about health care spending have focused on two issues: 1) the extent to which the increase in heath care spending is due to an increase in the **quantity** as opposed to the **price** of health care services, and 2) the efficiency and productivity of health care providers (e.g., hospital sectors, office of physicians, and long-term care).

The key to addressing both issues is a direct output measure of health care services—a measure that does not currently exist. In the National Accounts, output of the health care sector is measured by the volume of inputs, which includes labour costs for physicians, nurses and administrative staff, consumption of capital, and intermediate inputs. An input-based output measure assumes that there are no productivity gains in the health care sector. As a result, it does not provide a measure of productivity performance, nor does it allow a decomposition of total health care expenditures into price and output quantity components.

The main objective of this paper is to develop an experimental direct output measure for the Canadian hospital sector that can be used to address those issues. A large number of countries have already constructed a direct output measure of the hospital sector and other healthcare sectors.

## 1. What is the methodology for estimating the direct output of the hospital sector?

The methodology is outlined in the handbook on measurement of the volume of output of education and health services published by the Organisation for Economic Co-operation and Development (OECD) (Schreyer 2010). That approach is similar to those proposed in Atkinson (2005), the U.S. National Research Council (2010), and Eurostat (2001).

Measurement of direct output starts with a definition of the unit of output and weights used for aggregation. Ideally, the unit of output should capture the complete treatment, encompassing the path a patient takes through heterogeneous health care institutions to receive full and final treatment. This is known as disease-based approach.

But implementation of this ideal definition requires tracking individual patients across health care institutions; existing data rarely allow such linkages. In addition, the concept of "complete treatment" is problematic if the objective is to construct a direct output measure for specific institutions such as hospitals.

For practical reasons, Schreyer (2010) proposes a working definition of the unit of health care services—activities relating to an episode of treatment of a disease/condition provided by specific institutions.

Because episodes of treatment of different diseases/conditions involve different types of service, weights must be applied to construct the direct output measure. Schreyer (2010) proposes that unit costs be used to obtain a cost-weighted activity index. The Atkinson Report (Atkinson, 2005) and Dawson et al. (2005) recommend that the marginal value of a treatment be used to derive a value-weighted activity index as the ideal output measure, where the marginal value is based on the effect of the treatment on the patient's health outcome.

Because the effect of a treatment on health outcomes is often not available, the Atkinson report (Atkinson, 2005) and Dawson et al. (2005) conclude that the **cost-weighted activity index** is a practical approach for constructing the direct output measures for the hospital sector.

## 2. What is the main weakness of the cost-weighted activity index for measuring the output of the hospital sector?

A cost-weighted activity index, when inappropriately constructed, might introduce a substitution bias. Substitution bias arises when a shift in the composition of treatments (from inpatient to outpatient treatment) occurs, and inpatient treatment and outpatient treatment are assigned to different case types and are aggregated with their respective unit costs even though they both have the same effect on outcome. If outpatient treatment is less expensive, a cost-weighted activity index will indicate a decline in the hospital sector's volume of output. This is counterintuitive, since the volume of hospital service under the above assumption does not change when outpatient and inpatient treatments have the same effect on health outcomes and are valued equally by patients.

This counterintuitive result derives from an implicit assumption in the cost-weighted activity index: a treatment with lower unit costs has lower quality than a treatment with higher unit costs. But if treatments have a similar effect on health outcomes, they should have the same quality. An appropriate measure, for the example chosen, would show no change in the volume of hospital output and a decline in the price of that output as a result of the shift toward cheaper outpatient treatment.

The bias can be removed by grouping treatments with similar health outcomes in the same case types. This is not always feasible, as outpatient and inpatient cases are often assigned to different case types using different classification systems.

A **value-weighted activity index** captures such quality changes and does not suffer from substitution bias. For a value-added activity index, weights for aggregating treatments are based on the effect of treatments on health outcomes. To the extent that shifts from inpatient treatment to less expensive outpatient treatment have no effect on health outcomes, a value-weighted index will show a decline in the price of the hospital output but no change in the volume of hospital output.

## 3. What are the main data sources for estimating the direct output of the hospital sector in Canada?

The direct output measure of the hospital sector constructed in this paper covers all provinces except Quebec, for which consistent time-series data are not available. The nominal value of the hospital sector is estimated as total hospital expenditures, which are obtained from the income statements of all hospitals in the Canadian MIS Database (CMDB).

The data on unit costs and number of inpatient and outpatient cases by case types are obtained from the hospital discharge register maintained by the Canadian Institute for Health Information (CIHI): Discharge Abstract Database (DAD) and National Ambulatory Care Reporting System (NACRS). The DAD contains administrative, clinical and demographic information on hospital inpatients in all provinces except Quebec and it also contains information on outpatients in all provinces except Quebec, Ontario, and Alberta. Outpatient data for Ontario are from the NACRS.

## 4. What is the experimental estimate of the output and productivity growth of the hospital sector?

The preferred estimate is the cost-weighted activity index based on the detailed case type aggregation and corrected for substitution bias. This "quality" adjusted estimate of hospital sector output over the 2002-to-2010 period rose 4.3% per year. The price index of hospital sector output derived from the quality-adjusted volume index measure increased 2.7% per year.

Growth in the price of the hospital sector is slightly higher than growth in the price of gross domestic product over that period (2.5% per year).

Labour productivity calculated as the ratio of output to hours worked in the Canadian hospital sector is estimated to have increased 2.6% per year over the 2002-to-2010 period. This represents annual growth of 4.3% for output and 1.7% for hours worked.

## 5. What is the magnitude of the substitution bias in the cost-weighted volume index of the output of hospital sector, when inappropriately constructed?

The analysis reveals a large substitution bias in the cost-weighted volume index of output of the hospital sector when inpatient and outpatient cases are aggregated using their respective unit costs as weights. The bias is estimated to be about 2.6% to 3.3% annual growth in the volume index of the output of hospital sector for the period 2002 to 2010.

The substitution bias represents quality improvements stemming from shifts toward outpatient care that are not captured in the normal cost-weighted activity index.

The results of this study support the OECD recommendation that inpatient and outpatient cases not be separated for estimating the cost-weighted activity index (Schreyer 2010). Rather, they should be grouped together if they make a similar contribution to health outcomes.

## 6. Does the level of aggregation of case types affect the estimate of the volume index of output of hospital sector?

The level of detail in the classification of treatments may introduce a bias when more aggregated levels of classification of patient cases are used. This is referred to as aggregation bias.

The level of aggregation of case types is found to affect the estimated volume index of output of hospital sector. Compared with a more detailed level of disaggregation of patient cases (600 case types for inpatients, and 100 to 300 case types for outpatients), a higher level of disaggregation (about 20 case types for both inpatients and outpatients) reduced the growth in the volume index of the hospital sector by 0.6 percentage points per year.

# 1 Introduction

Health care is an important economic activity in Canada (CIHI, 2011*a*). As a share of gross domestic product (GDP), health care expenditures rose from 7.0% in 1975 to 11.7% in 2011.

Recent discussions about health care spending have focused on two issues: 1) the extent to which the increase is due to an increase in the quantity as opposed to the price of health care services, and 2) the efficiency and productivity of health care providers.

For example, the Canadian Institute for Health Information (CIHI) examined sources of the increase in hospital expenditures between 1998 and 2008. Using the GDP price index as a proxy for the price index of hospital expenditures, CIHI (2012*a*) reported that total hospital expenditures rose 6.7% annually over the period, 2.8% of which was due to price changes. The remaining 3.9% was due to an increase in the quantity of hospital services, as a result of factors such as population growth, population aging, and technical progress and innovation. In a related study, CIHI (2011*b*) examined factors behind the increase in total health care expenditures.

With regard to the efficiency and productivity of health care providers, Sharpe, Bradley and Messinger (2007) noted that accurate measures of health care output and productivity are essential and recommended that more resources be allocated to develop better measures for Canada's health care sector.

The key to addressing both issues is a direct output measure of health care services—a measure that does not currently exist. In the National Accounts, output of the health care sector is measured by the volume of inputs, which includes labour for physicians, nurses and administrative staff, consumption of capital, and intermediate inputs (Statistics Canada, 2001). An input-based output measure assumes that there are no productivity gains in the health care sector.[1] As a result, it does not provide a measure of productivity performance, nor does it allow a decomposition of total health care expenditures into price and output quantity components.

The main objective of this paper is to develop an experimental direct output measure for the Canadian hospital sector. The focus is on the hospital sector because hospitals make up the largest component of health care spending, and the data are readily available. Hospital expenditures totalled $60.5 billion in 2011 and accounted for 29.2% of total health spending that year (CIHI, 2011*a*).[2]

The direct output measure developed here is based on the number of "activities" in hospitals, with activities defined as episodes of treatment of diseases and conditions. Because the treatment of different diseases/conditions involves different types of service, weights must be applied to construct the direct output measure. Previous studies have proposed two alternative weights: one based on the unit costs of treatments, and the other based on the value of treatments to patients (the effect on the patient's health outcome) (Atkinson 2005; Dawson et al. 2005; Schreyer 2010). These studies acknowledge that the former is the most practical. Accordingly, this analysis constructs a direct output measure of the hospital sector using unit costs as weights—the cost-weighted activity index.

The cost-weighted activity index, when calculated inappropriately, introduces a bias in the estimate as a result of a shift from inpatient treatment toward cheaper outpatient treatment with improved or similar health outcomes (Schreyer 2010, 2012). The index will show a decline in the volume of hospital care, which is contrary to intuition that, because of the substitution of one mode of treatment for another, the volume of hospital care increased, or at least, did not change.

1. The input-based output measure implies that no multifactor productivity growth occurs in the health care sector.
2. Other health care expenditure categories include physicians, drugs, and other health institutions.

This paper examines the substitution bias in the cost-weighted activity index as it is often calculated. It also examines aggregation bias or the effect of using various levels of aggregation of case types to calculate the direct output measure. This is relevant because countries often classify case types at a high level of aggregation to overcome problems that are created by changes over time in classification at a detailed level.

Two previous Statistics Canada studies developed direct output measures for hospital care. Kitchen (1997) constructed a direct output measure for the hospital sector as the cost-weighted sum of the number of treatments for inpatients, outpatients and chronic care during the 1986-to-1992 period. Statistics Canada (2001) extended the estimate for inpatient care to take into account differences in unit costs across 500 categories of inpatient treatments.

This study is related to Yu and Ariste (2009) who constructed a direct output measure for the hospital sector as a cost-weighted activity index for the periods 1996 to 2000 and 2003 to 2005. The present analysis differs in that it attempts to correct for substitution and aggregation biases.

The rest of the paper is organized as follows. Section 2 outlines the methodology used to construct the direct output measure. Section 3 describes the data sources. Section 4 presents an estimate of hospital sector output and examines potential bias in the estimate. Section 5 concludes.

# 2 Methodology

This section summarizes the approaches used to measure the output of the hospital sector and highlights challenges, issues, and data constraints that national statistical agencies encounter in implementing the various approaches.

This study employs the approach in the handbook on measurement of the volume of output of education and health services published by the Organisation for Economic Co-operation and Development (OECD) (Schreyer 2010). That approach is similar to those proposed by the Atkinson review of the measurement of government output and productivity for the National Accounts (Atkinson 2005), the U.S. National Research Council (2010), and Eurostat (2001). It has been adopted by a number of countries to develop a direct output measure of the health care sector (Schreyer 2010).

The Systems of National Accounts (SNA) 1993 (United Nations et al. 1993) and SNA 2008 (United Nations et al. 2010) recommended an output-based approach for measuring the volume of health sector output.[3] Eurostat (2001) made similar recommendations and provided detailed guidance toward implementation in its *Handbook on Price and Volume Measures in National Accounts*. The handbook became European law, obliging member states to implement the recommendations.

Measurement of direct output starts with a definition of the unit of output and weights used for aggregation. For the goods-producing business sector, the unit of output and the weights used for aggregation are straightforward. For example, to construct the direct output measure of the automobile manufacturing sector, the unit of output is defined as the number of cars manufactured, and market prices are used for aggregation. The hospital sector, however, is less straightforward.

Schreyer (2010) defines the unit of health services as the treatment of a disease or condition. Ideally, the unit of output should capture the complete treatment, encompassing the path a

3. The principles for constructing the output-based measures of non-market services, including health care, go back to work by Hill (1975).

patient takes through heterogeneous health care institutions to receive full and final treatment. This definition of the target measure, known as a disease-based estimate of health care output, is similar to that used by the Eurostat Handbook (Eurostat 2001), Berndt et al. (2001), Aizcorbe et al. (2008) and Triplett (2001).

Implementation of this ideal definition requires tracking individual patients across health care institutions to measure complete treatment; existing data rarely allow such linkages. In addition, the concept of "complete treatment" is problematic if the objective is to construct a direct output measure for specific institutions such as hospitals. For practical reasons, Schreyer (2010) proposes a working definition of the unit of health care services—activities relating to an episode of treatment of a disease/condition provided by specific institutions.

Because episodes of treatment of different diseases/conditions involve different types of service, weights must be applied to construct the direct output measure. Typically, market prices provide such weights, but because there are no market prices for most hospital services, Schreyer (2010) proposes that unit costs be used to obtain the cost-weighted activity index. The Atkinson Report (Atkinson 2005) and Dawson et al. (2005) recommend that the marginal value of a treatment be used to derive a value-weighted activity index as the ideal output measure, where the marginal value is based on the effect of the treatment on the patient's health outcome.

In Canada, the public sector (federal, provincial and municipal governments) provides and finances 90% of hospital services. If well-functioning markets existed for hospital services, unit costs of treatments would tend to be the same as their value to patients, and market prices (which tend to be equal to unit costs and value to patients) should be used for aggregation. But because there are no markets for most publicly financed hospital services, unit costs of treatments may be different than values to patients, and consequently, the choice of weights matters for the direct output measure.

Because the effect of a treatment on health outcomes is often not available, the Atkinson report (Atkinson 2005) and Dawson et al. (2005) conclude that the cost-weighted activity index is a practical approach for constructing the direct output measures for the hospital sector. However, a cost-weighted activity index might introduce a substitution bias (Schreyer 2010, 2012). Substitution bias arises when a shift in the composition of treatments (from inpatient to outpatient treatment) occurs, and inpatient treatment and outpatient treatment are assigned to different case types with different unit costs even though they both have the same effect on outcome. If outpatient treatment is less expensive, a cost-weighted activity index will indicate a decline in the hospital sector's volume of output when there are shifts from inpatient to outpatient care. This is counterintuitive, since the volume of hospital service under the above assumption does not change when outpatient and inpatient treatments have same effect on health outcomes and are valued equally by patients.[4]

This counterintuitive result derives from an implicit assumption in the cost-weighted activity index: a treatment with lower unit costs has lower quality than a treatment with higher unit costs. But if treatments have a similar effect on health outcomes, they should have the same quality.[5] An appropriate measure, for the example chosen, would show no change in the volume of hospital output and a decline in the price of that output as a result of the shift toward cheaper outpatient treatment.

4. The substitution bias also exists in the relative price level of hospital services that the OECD constructed in its pilot study, because inpatient and outpatient treatments were assigned different case types and different unit costs were used as weights for the two types of service (Schreyer 2010) (Koechlin, Lorenzoni and Schreyer 2010).
5. Quality is defined as characteristics of a product that consumers value. For treatment of a disease, "quality" is the effect on health outcomes. Triplett (2006) provided an extensive discussion of quality adjustment.

The bias can be removed by grouping treatments with similar health outcomes in the same case types (Schreyer 2010, 2012). This is not always feasible, as outpatient and inpatient cases are often assigned to different case types using different classification systems. And in some instances, there is no classification of case types for outpatient treatments.

Substitution bias arises from **quality** changes in hospital care that come from shifts between case types that the cost-weighted activity index does not capture. A **value-weighted** activity index captures such quality changes and does not suffer from substitution bias. For a value-weighted activity index, weights for aggregating treatments are based on the effect of treatments on health outcomes. To the extent that compositional shifts from inpatient treatment to less expensive outpatient treatment have no effect on health outcomes, a value-weighted index will show a decline in the price of the hospital output but no change in the volume of hospital output.[6]

To construct a cost-weighted activity index, treatments are assigned to various case types. The level of detail in the classification of treatments may introduce a bias when more aggregated levels of classification are used. This is referred to as "aggregation bias" in this paper.

The objective of this paper is to construct a cost-weighted activity index for the hospital sector and examine the magnitude of substitution and aggregation bias. Hospital sector output includes both inpatient and outpatient care. The unit of output is defined as the number of episodes of treatment that patients received in hospitals, specifically, the number of discharges by case type (patient statistics are derived from hospital discharge registers). In this report, the terms "case," "treatment," and "discharge" are used interchangeably.

The cost-weighted activity index of the volume of hospital sector output $Q$ is expressed as a Tornqvist aggregation of the number of patient cases, by case type, using unit costs as weights:

$$(\ln Q_t - \ln Q_{t-1}) = \sum_i \overline{s}_i (\ln q_t - \ln q_{t-1})$$

$$s_i^t = \frac{c_i^t q_i^t}{\sum_i c_i^t q_i^t}, \quad \overline{s}_i = 1/2(s_i^t + s_i^{t-1}), \tag{1}$$

where $q_t$ is the number of cases for case type $i$; $c_t$ is the unit cost per treatment for case type $i$; and $s_t$ is the share of case type $i$ in total costs.[7]

The volume index of the hospital sector output is then used to derive the price index of the hospital sector output.

An alternative approach is to construct the price index of hospital services and derive the volume index as deflated total expenditures of the hospital sector. The choice between the two methods is mainly driven by data availability. For example, Germany and Denmark use the deflation method and construct the price index of hospital services, while the Netherlands constructs the volume index of the output of hospital care (Schreyer 2010). The Bureau of Labour Statistics (BLS) uses the deflation method to construct the producer price index (PPI) of

6. A value-weighted index, in this context, may even show an increase in the volume of hospital output as the shifts towards less expensive outpatient treatments will often result in an increase in the total number of treatments. For example, as pointed out by Brent Diverty of the Canadian Institute for Health Information (CIHI), cataract surgery used to be an inpatient procedure; now the most common type of cataract surgery can take as little as 10 minutes. So many more treatments are being done.
7. In the estimation below, the case type for inpatients is further disaggregated based on the age of patients and the severity of the disease to obtain more homogeneous groups of patients with similar unit costs when the information is available.

hospital expenditures for the United States (Carton and Murphy 1996). The BLS samples the costs of inpatient and outpatient treatments and derives the price index of hospital expenditures as the weighted sum of unit costs of inpatient and outpatient treatments, using their cost shares as weights.[8]

In Canada, the unit cost (resource intensity weight) represents the relative resource intensity of inpatient and outpatient cases compared with the average inpatient case, which has a value of 1.0. To use the deflation method to calculate the price index of hospital sector output and then derive the volume index, the resource intensity weight (RIW) estimates need to be converted to monetary values by multiplying the RIWs by the appropriate Cost per Weighted Case (CPWC) values, as was done for the OECD pilot project on comparing price levels of hospital expenditures across OECD countries (Koechlin et al. 2010). In contrast, it is more straightforward to construct the volume index of hospital sector output and then calculate the implicit price index as the RIW values can be used directly to estimate the share of case types in total costs for estimating the volume index.

To examine the substitution bias in the cost-weighted activity index, inpatients and outpatients in the same case types are combined, and the same unit costs are used to weight inpatients and outpatients belonging to the same case types. The resulting estimate is compared with the estimate derived from classifying inpatient and outpatient cases as distinct activities, and then weighting them using different unit costs.

The approach adopted for the present study has been suggested by Schreyer (2010, 2012), but has not previously been implemented because classifications for outpatient treatments are often not the same as those for inpatient treatments, or are lacking altogether.

An alternative is to assume that, without the shift toward outpatient treatment, the growth of inpatient and outpatient care would be similar. Therefore, the relatively faster increase of outpatients would be entirely due to substitution. Growth of outpatient cases that exceeds the growth of inpatient cases is weighted using the unit costs for average inpatients to derive an alternative direct output measure. This assumes that outpatient treatment yields the same health care services as inpatient treatment. The difference between the new and original estimates provides a measure of substitution bias.

# 3 Data

Hospitals are involved in inpatient care, outpatient care, and activities such as research, education and social services. Inpatient and outpatient services accounted for 92.5% of total hospital expenditures in 2007, down slightly from 94.6% in 1999 (CIHI 2012*a*).

The direct output measure of the hospital sector constructed in this paper covers all provinces except Quebec, for which consistent time-series data are not available.[9] The nominal value of the hospital sector is estimated as total hospital expenditures, which are obtained from the income statements of all hospitals in the Canadian MIS Database (CMDB).

The data on inpatient and outpatient cases are from the hospital discharge register. The volume index constructed in this paper covers inpatient and outpatient treatment, but not other hospital activities, which account for only about 5% of total hospital expenditures.

8. Because the BLS also makes a distinction between inpatient and outpatient treatments, its hospital price index may introduce a substitution bias similar to that examined here.
9. Outpatient data are not available for Alberta, and so are excluded from the estimates.

The databases used for estimating the nominal value and the volume index of the output of the hospital sector have the same coverage of hospitals (CIHI 2011*c*).[10] The volume index of the hospital sector output estimated from the hospital discharge register can be compared with total hospital expenditures from the CMDB to derive a price deflator for hospital sector output.

## 3.1 Total hospital expenditures

Total expenditures for Canadian hospitals are from the CMDB, maintained by CIHI (CIHI 2011*c*). The CMDB includes financial information from hospital balance sheets and income statements.[11] Total hospital expenditures are published in National Health Expenditure Trends (CIHI 2011*a*), and constitute the source data used to estimate the gross output of the hospital sector in the Canadian System of National Accounts.[12]

## 3.2 Inpatients

Data on inpatient treatment are from the Discharge Abstract Database (DAD), maintained by CIHI (CIHI 2012*b*). The DAD contains administrative, clinical and demographic information on hospital inpatients in all provinces except Quebec.

The DAD assigns inpatients to one of 21 Major Clinical Categories (MCCs) (see below) based on their "most responsible" diagnosis. Inpatients in each MCC are further assigned to one of about 600 Case Mixed Groups (CMGs), which aggregate cases with similar clinical and resource utilization characteristics. These data may be further disaggregated by patient age or disease severity to obtain more homogeneous groups of patients with similar resource requirements. For 2009, there are 21 MCCs and 570 CMG categories. The number of age groups and complexity/comorbidity categories changed slightly over time: for the 2002-to-2004 period, four complexity levels and three age groups; after 2004, more detailed age groups and six comorbidity levels (CIHI 2007*b*).[13]

10. Hospitals in the Discharge Abstract Database (DAD) can be linked to the CMDB, which contains hospital income statements and balance sheets.
11. In provinces and territories where hospitals are part of a regional health authority, regional hospital data are submitted to the CMDB.
12. The CMDB does not provide expenditure data on Quebec hospitals while the National Health Expenditure Database (NHEX) provides data on Quebec hospitals.
13. Changes in CMG classification may introduce inconsistency in the estimated volume index of hospital sector output over time.

**Major Clinical Category (MCC)**

**Numbers and titles**

1 Diseases and disorders of the nervous system
2 Diseases and disorders of the eye
3 Diseases and disorders of ear, nose, mouth and throat
4 Diseases and disorders of the respiratory system
5 Diseases and disorders of the circulatory system
6 Diseases and disorders of the digestive system
7 Diseases and disorders of the hepatobiliary system and pancreas
8 Diseases and disorders of the musculoskeletal system and connective tissue
9 Diseases and disorders of the skin, subcutaneous tissue and breast
10 Diseases and disorders of the endocrine system, nutrition and metabolism
11 Diseases and disorders of the kidney, urinary tract and male reproductive system
12 Diseases and disorders of the female reproductive system
13 Pregnancy and childbirth
14 Newborns and neonates with conditions originating in the perinatal period
15 Diseases and disorders of the blood and lymphatic system
16 Multisystemic or unspecified site infections
17 Mental diseases and disorders
18 Burns
19 Significant trauma, injury, poisoning and toxic effects of drugs
20 Other reasons for hospitalization
99 Miscellaneous case mixed groups and ungroupable data

**Source:** Canadian Institute for Health Information (2007*b*)

Unit costs, or resource intensity weights (RIWs), are calculated for inpatients in a specific CMG, age group and complexity/comorbidity category.[14] All RIWs are relative to an average inpatient case, which is assigned an RIW of 1.0. For example, a patient with an RIW of 2.0 would require twice as many resources during the course of hospital treatment as the average inpatient.[15]

In this paper, RIWs are used to aggregate inpatient cases across case types to derive the volume index of inpatient care in hospitals.

## 3.3 Outpatients

Data on outpatient services for all provinces except Ontario, Quebec and Alberta are also from the DAD. Outpatient data for Ontario are from CIHI's National Ambulatory Care Reporting System (NACRS). Outpatient data for Alberta and Quebec are not available for the period covered in this paper.

The DAD makes a distinction between inpatient and outpatient treatments. Inpatient and outpatient cases are assigned to the same case types at the aggregate level of classification, but to different case types at more detailed levels. Outpatient cases and day procedures are assigned to one of 21 MCCs at the aggregate level, and to one of around 100 Day Procedure Groups (DPGs) at the detailed level according to the principal procedure recorded. Those

14. The RIW is a measure of the relative amount of hospital resources used to treat an inpatient or outpatient. RIWs are calibrated annually so that the average inpatient acute care case in Canada has a value of one (CIHI 2007*b*).
15. Unit costs for atypical cases (which include acute care transfers, sign out, and death) are calculated using a per diem-based approach. Unit costs for atypical cases are then expressed relative to that for an average case (CIHI, 2007*b*).

assigned to the same DPG constitute a homogeneous group with similar clinical episodes and requiring similar resources.

Outpatient cases and day procedures in the NACRS are assigned to one of about 20 Major Ambulatory Clusters (MACs) at the aggregate level, and to one of about 300 case types using the Comprehensive Ambulatory Classification System (CACS). The CACS provides a more detailed classification of outpatient cases than DPGs in the DAD, but the classifications are similar, and MACs can be mapped to MCCs.

Each outpatient case is assigned an RIW. Because the RIW for outpatient cases is comparable to the RIW for inpatient cases (Hicks and Zhang 2003), the volume index of inpatient and outpatient cases can be combined to derive the volume index of the output of the hospital sector.

This study focuses on 2002 to 2010, because the data are consistent and no major changes in the classification of inpatient and outpatient cases were made during the period.[16] The two hospital register databases used in this analysis pertain to the April-March fiscal year; the data were converted to calendar years based on the month of patient discharge.

16. The classification of case types at the detailed level changed for 2004/2005. The volume index for that year was estimated based on the higher level of aggregation.

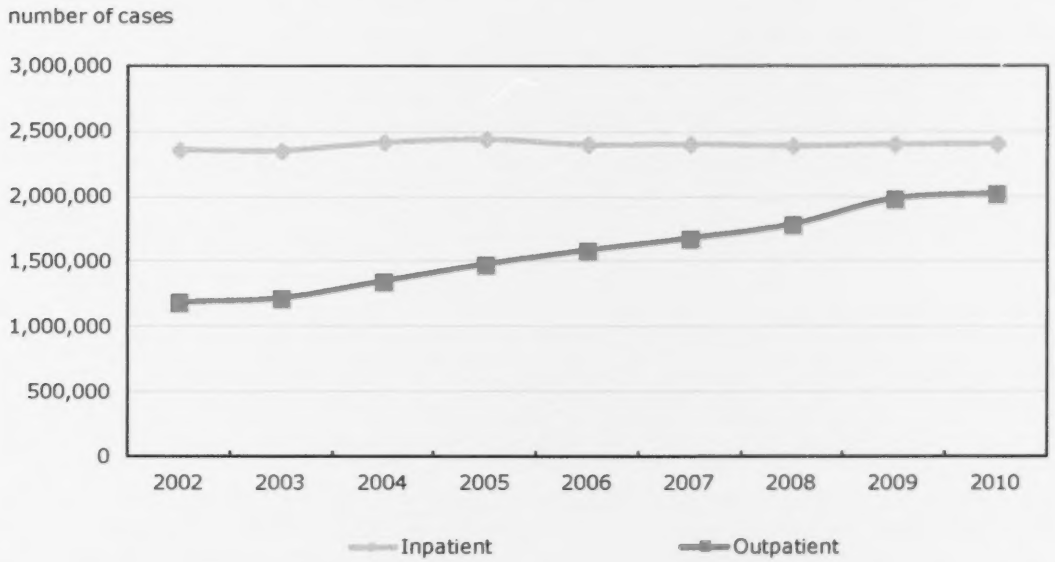
# 4 Direct output measures

This section presents direct output measures of the hospital sector for 2002 to 2010 for all provinces except Quebec,[17] for which consistent data are not available. Because outpatient data are not available for Alberta,[18] it was assumed that growth in the volume index of outpatient care in Alberta is equal to the average growth of outpatient care in the other provinces.

From 2002 to 2010, the number of inpatient cases rose slightly from 2.36 million to 2.41 million (Chart 1). However, the number of outpatient cases and day procedures nearly doubled from 1.18 million to 2.02 million, an increase that has been attributed to a shift in elective surgeries from an inpatient to a day-surgery setting (CIHI 2007*a*).

**Chart 1**

**Number of hospital inpatient and outpatient cases, Canada, 2002 to 2010**




**Note:** Authors' estimates.
**Sources:** Canadian Institute for Health Information, Discharge Abstract Database and National Ambulatory Care Reporting System.

This analysis first presents the cost-weighted activity index of hospital sector output when inpatient and outpatient cases are assigned to different case types, and different unit costs are used to aggregate inpatient and outpatient cases. Specifically, the index is estimated by aggregating inpatient and outpatient cases at the most detailed classification level. Inpatient cases are further disaggregated by patient age group and by disease/condition severity. Substitution and aggregation biases are then examined. Finally, the estimate is compared with the estimate from the Canadian System of National Accounts.

17. Quebec accounted for about 20% of hospital expenditures over the 2002-to-2010 period.
18. Alberta accounted for about 12% of hospital expenditures over the 2002-to-2010 period.

## 4.1 Cost-weighted activity index, inpatient and outpatient cases assigned to different case types

Table 1 presents the volume index of hospital sector output for the 2002-to-2010 period that results when inpatient and outpatient cases are assigned to different case types and different unit costs are used to weight them.

**Table 1**

**Direct output measure of the hospital sector, Canada, 2002 to 2010**

| | All | | Inpatient | | Outpatient | |
|---|---|---|---|---|---|---|
| Years | Output | Cases | Output | Cases | Output | Cases |
| | **index** | **thousands** | **index** | **thousands** | **index** | **thousands** |
| 2002 | 100.0 | 3,541 | 100.0 | 2,357 | 100.0 | 1,184 |
| 2003 | 100.0 | 3,563 | 99.5 | 2,349 | 104.2 | 1,215 |
| 2004 | 103.2 | 3,760 | 100.8 | 2,416 | 122.2 | 1,345 |
| 2005 | 105.3 | 3,917 | 101.3 | 2,443 | 137.1 | 1,474 |
| 2006 | 103.7 | 3,980 | 98.3 | 2,399 | 148.4 | 1,581 |
| 2007 | 105.9 | 4,076 | 99.6 | 2,403 | 158.3 | 1,673 |
| 2008 | 108.3 | 4,168 | 100.7 | 2,389 | 170.9 | 1,779 |
| 2009 | 112.4 | 4,376 | 103.2 | 2,401 | 188.9 | 1,976 |
| 2010 | 114.8 | 4,424 | 105.2 | 2,406 | 194.1 | 2,018 |
| | | | **percent** | | | |
| Average annual growth, 2002 to 2010 | 1.7 | 2.8 | 0.6 | 0.3 | 8.6 | 6.9 |

**Notes:** Excludes Quebec. The volume index of output is set equal to 100 in 2002. Authors' estimates.
**Sources:** Canadian Institute for Health Information, Canadian MIS Database, Discharge Abstract Database, and National Ambulatory Care Reporting System.

The volume index of **inpatient** care increased 0.6% per year. This growth was faster than the increase in the unweighted number of inpatient cases (0.3%). The difference signals a change in the nature of inpatient cases toward those that are more resource-intensive (for example, elderly patients) (CIHI 2007*a*), as a result of the aging of the population. Other factors contributing to the difference include an increase in cases that involve resource-intensive technologies and the general shift from inpatient to outpatient care.

The volume index of **outpatient** care rose 8.6% per year. This growth, too, was faster than the increase in the unweighted number of outpatient cases (6.9%), and reflects more use of resource-intensive technologies.

The volume index of the **hospital sector** overall is obtained by aggregating the volume indices of inpatient and outpatient care using their relative cost share as weights.[19] The volume index of the hospital sector increased 1.7% per year, which was slower than the increase in the total number of inpatient and outpatient cases (2.8%). The difference is mainly due to compositional shifts in hospital care toward outpatient treatment, which is less resource-intensive, and therefore, less expensive than inpatient treatment. Thus, the shift, or "substitution," reduced the growth of the volume index of hospital care.

Using the same databases, Yu and Ariste (2009) constructed a cost-weighted activity index for the hospital sector (excluding Quebec) for 1996 to 2000 and for 2003 to 2005. The estimate for

19. The share of total costs attributable to day procedures is calculated from resource intensity weights in the Discharge Abstract Database (DAD). It was 11.7% in 2002 for the eight provinces whose statistics on both inpatient cases and day procedures are included in the DAD (Quebec and Alberta are excluded).

2003 to 2005 in the present analysis is almost identical to theirs: both indicate growth of 2.6% per year in the volume index of the hospital sector output (data not shown).

For the Table 1 estimates, inpatient and outpatient cases were assigned to detailed case types. To assess the effect of level of aggregation, an alternative estimate is derived by using a higher level of aggregation—the Major Clinical Category (MCC).[20] The unit cost of an MCC is calculated as an average of unit costs among the detailed case types that comprise the MCC. Differences in unit costs between age groups and disease/condition severity are not taken into account.

Use of higher levels of aggregation reduced the growth in the volume index of the hospital sector by 0.6 percentage points per year (Table 2). This aggregation bias appears in both inpatient and outpatient care, reducing annual growth in the volume index of inpatient care by 0.6 percentage points, and in the volume index of outpatient care by 0.4 percentage points.

**Table 2**

**Effect of the level of aggregation on the direct output measure of the hospital sector, Canada, 2002 to 2010**

| | Annual average growth | | |
|---|---|---|---|
| | Detailed level | Broad level | Difference |
| | percent | | |
| **All** | | | |
| Volume index of output | 1.7 | 1.2 | -0.6 |
| Number of cases | 2.8 | 2.8 | 0.0 |
| Composition | -1.1 | -1.6 | -0.6 |
| **Inpatient** | | | |
| Volume index of output | 0.6 | 0.0 | -0.6 |
| Number of cases | 0.3 | 0.3 | 0.0 |
| Composition | 0.4 | -0.2 | -0.6 |
| **Outpatient** | | | |
| Volume index of output | 8.6 | 8.2 | -0.4 |
| Number of cases | 6.9 | 6.9 | 0.0 |
| Composition | 1.6 | 1.2 | -0.4 |

**Notes:** The detailed level of aggregation consists of about 600 case types for inpatients, and 100 to 300 case types for outpatients. The broad level of aggregation consists of about 20 categories for both inpatients and outpatients. Authors' estimates.

**Sources:** Canadian Institute for Health Information, Canadian MIS Database, Discharge Abstract Database, and National Ambulatory Care Reporting System.

## 4.2 Cost-weighted activity index, inpatient and outpatient cases assigned to same case types

To the extent that inpatient and outpatient treatments of the same disease/condition have a similar effect on health outcomes but there has been a shift towards less expensive outpatients, the cost-weighted index will underestimate growth.

To assess the substitution bias that occurs when inpatient and outpatient cases are assigned to different case types, they are grouped using the same classification and assigned to one of 21 MCCs. Relative unit costs for inpatient cases are used as weights to aggregate inpatient and outpatient treatments belonging to the same case type. This is compared with the cost-weighted activity index of the hospital sector when different unit costs for inpatient and outpatient cases

20. For outpatient cases and day procedures for Ontario from the National Ambulatory Care Reporting System, major ambulatory clusters are used to derive the estimate of the volume index.

belonging to the same MCCs are used for aggregation. The difference between the two estimates is a measure of the substitution bias in the cost-weighted activity index.

The substitution bias is considerable (Table 3). Removal of the bias increased the growth of the volume index of the hospital sector output during the 2002-to-2010 period by 2.6 percentage points.

**Table 3**

**Substitution bias in the direct output measure of the hospital sector, Canada, 2002 to 2010**

| | Annual average growth | | |
|---|---|---|---|
| | Distinct grouping | Same grouping | Difference |
| | percent | | |
| **All** | | | |
| Volume index of output | 1.2 | 3.7 | 2.6 |
| Number of cases | 2.8 | 2.8 | 0.0 |
| Composition | -1.6 | 0.9 | 2.5 |
| **Inpatient** | | | |
| Volume index of output | 0.0 | 0.0 | 0.0 |
| Number of cases | 0.3 | 0.3 | 0.0 |
| Composition | -0.2 | -0.2 | 0.0 |
| **Outpatient** | | | |
| Volume index of output | 8.2 | 7.4 | -0.8 |
| Number of cases | 6.9 | 6.9 | 0.0 |
| Composition | 1.2 | 0.5 | -0.8 |

**Notes:** "Distinct grouping" refers to assignment of inpatient and outpatient cases to distinct Major Clinical Categories (MCCs) with different unit costs. "Same grouping" refers to assignment of inpatient and outpatient cases to the same MCCs using the same unit costs. Authors' estimates.

**Sources:** Canadian Institute for Health Information, Canadian MIS Database, Discharge Abstract Database, and National Ambulatory Care Reporting System.

The substitution bias can be regarded as resulting from quality changes in hospital service that the normal cost-weighted activity index fails to capture (Schreyer 2010, 2012), because it assumes that outpatient treatments with lower unit costs have lower quality than do inpatient treatments of the same disease/condition. Thus, the cost-weighted activity index will show a decline in volume of output when treatment shifts from inpatient to outpatient care. If inpatient and outpatient treatments have a similar effects on health outcomes, a cost-weighted activity index that was adjusted for quality measure would show no decline in volume of output.

To remove substitution bias and capture quality changes from shifts in treatments between case types, Schreyer (2010, 2012) recommends that inpatient and outpatient cases be grouped together if they have a similar contribution to health outcomes. In practice, this is not always feasible, because inpatient and outpatient cases are often assigned to case types using different classification systems. And sometimes, outpatient cases are not classified at all. In such instances, a cost-weighted activity index may seriously underestimate the volume index of the hospital sector when there is a large shift toward outpatient treatment, as has occurred in Canada.

## 4.3 Cost-weighted activity index from a counterfactual

The magnitude of substitution bias has been examined using a broad level of disaggregation of patient cases in Subsection 4.2. Ideally, it should be examined using a more detailed level of disaggregation. To assess the robustness of the estimated substitution bias, this subsection provides an alternative estimate at a more detailed level using the assumption that the growth of inpatient cases and outpatient cases would be similar without the substitution. Therefore, the

difference in the growth rates of outpatient and inpatient cases is entirely due to the substitution.[21] The growth of outpatient cases exceeding the growth of inpatient cases is weighted using the unit cost for average inpatient cases. The difference between the new estimate and the original estimate provides an assessment of the substitution bias in the cost-weighted activity index of the hospital sector.

The results of this counterfactual reveal a similarly large substitution bias in the cost-weighted activity index (Table 4). The estimated volume index of the hospital sector from the counterfactual increased 4.0% per year during the 2002-to-2010 period, compared with 1.7% per year for the cost-weighted activity index.

**Table 4**

**Alternative estimates of direct output measure of the hospital sector (average annual growth in percent, 2002 to 2010), Canada**

| | Average annual growth | | |
|---|---|---|---|
| | Volume index of output | Price index of output | Nominal expenditure |
| | percent | | |
| Detailed level of distinct case groups for inpatients and outpatients | 1.7 | 5.2 | 7.0 |
| Broad level of distinct cases types for inpatients and outpatients | 1.2 | 5.8 | 7.0 |
| Broad level of same case types for inpatients and outpatients | 3.7 | 3.3 | 7.0 |
| Counterfactual estimate | 4.0 | 3.0 | 7.0 |
| Preferred estimate | 4.3 | 2.7 | 7.0 |

**Note:** Authors' estimates.
**Sources:** Canadian Institute for Health Information, Canadian MIS Database, Discharge Abstract Database, and National Ambulatory Care Reporting System.

## 4.4 Productivity growth of the hospital sector

Table 4 summarizes the alternative estimates of the direct output measure of the hospital sector and presents both volume and price indices.[22] The price index is derived by dividing total hospital expenditures by the volume index of output.

The preferred estimate is the cost-weighted activity index based on the detailed case type aggregation and corrected for substitution bias. Growth in this quality-adjusted cost-weighted activity index of hospital sector output can be calculated as the growth in the volume index estimated from using different classifications for inpatient cases and outpatient cases at a detailed level (1.7% per year) plus the substitution bias in that estimate (2.6%). Alternatively, it can be calculated as the sum of the estimate from using the same classification for inpatient and outpatient cases at a broad level (3.7%) plus the aggregation bias in that estimate (0.6%).

The quality-adjusted estimate of hospital sector output over the 2002-to-2010 period rose 4.3% per year. The price index of hospital sector output derived from the quality-adjusted volume index measure increased 2.7% per year. Growth in the price of the hospital sector is slightly higher than growth in the price of gross domestic product over that period (2.5% per year).

21. CIHI (2007*b*) attributes the relative growth difference between inpatient and outpatient cases mostly to a shift in elective surgeries from an inpatient to a day-surgery setting.
22. In addition to inpatient and outpatient care, hospitals are also involved in activities such as research, education and social services. As the Inpatient and outpatient services account for a predominant share (92.5%) of total hospital expenditures (CIHI 2012*a*), the direct output measure of inpatient and outpatient care should provide a good estimate of the hospital sector output.

Table 5 compares the quality-adjusted estimate of the direct output measure of the hospital sector with the output measure from the input-based approach in the Canadian System of National Accounts for the 2002-to-2008 period. Because the direct output measure of the hospital sector examined in this paper does not include Quebec, Quebec is also not included in the estimate derived from the National Accounts.

**Table 5**

**Comparison of National Accounts estimates of hospital sector output and direct output measures of the hospital sector, Canada, 2002 to 2008**

| | Average annual growth | |
|---|---|---|
| | National accounts | Experimental estimates |
| | percent | |
| Volume index of output | 4.1 | 4.2 |
| Price index of output | 2.7 | 2.8 |
| Nominal hospital output | 6.8 | 6.9 |

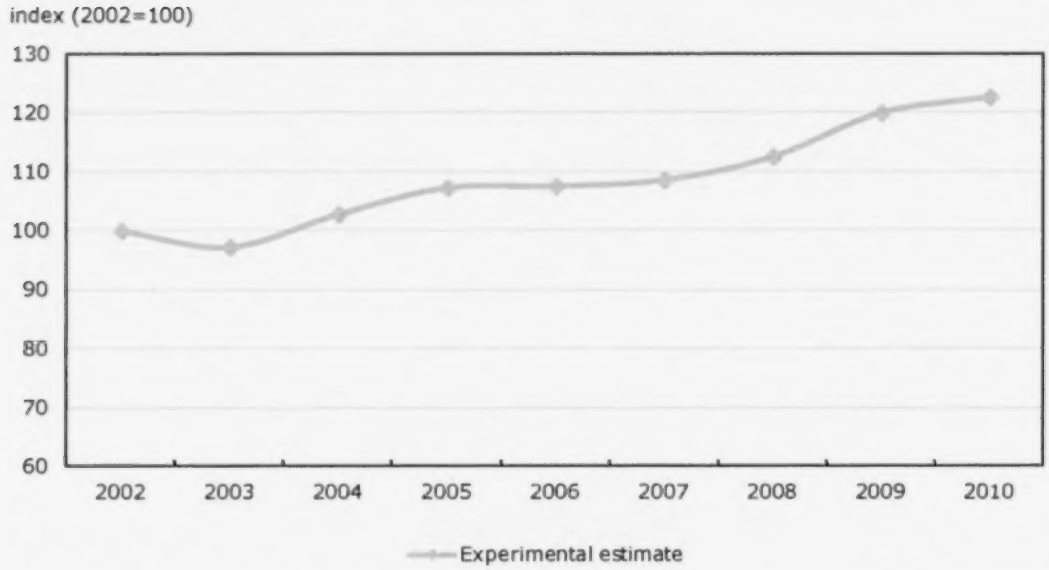
**Note:** Authors' estimates.
**Sources:** Statistics Canada, Canadian System of National Accounts; and Canadian Institute for Health Information, Canadian MIS Database, Discharge Abstract Database, and National Ambulatory Care Reporting System.

Nominal gross output of the hospital sector in the National Accounts is estimated from total hospital expenditures in the Canadian MIS Database. Nominal gross output of the hospital sector is about 10% higher than total hospital expenditures, a difference that is quite stable over the period. The growth rate of nominal gross output in the hospital sector is similar to the growth rate in total hospital expenditures. The direct output measure of the hospital sector is estimated to have increased 4.2% per year, while the output measure of the hospital sector estimated as the volume index of inputs in the National Accounts, which is based on the growth rate of all inputs, increased 4.1% per year.

Chart 2 displays an estimate of labour productivity (ratio of the volume index to hours worked) based on the quality-adjusted direct output measure constructed in this paper. Hours worked for the hospital sector is obtained from Statistics Canada's Labour Productivity Program (Maynard 2005), estimated as total employment times average hours worked per worker. The employment data are from the Survey of Employment, Payrolls and Hours, which collects administrative information on employment for all establishments. The data on hours worked are from the Labour Force Survey, a monthly household survey that collects employment data for all workers.

**Chart 2**

**Estimated labour productivity in the Canadian hospital sector, 2002 to 2010**




**Note:** Authors' estimates.
**Source:** Statistics Canada, Labour Productivity Program.

Labour productivity in the Canadian hospital sector increased 2.6% per year over the 2002-to-2010 period. This is derived from an annual growth of 4.3% for output and 1.7% for hours worked.

Based on the growth accounting framework of Solow (1957) and Jorgenson and Griliches (1967), Table 6 decomposes growth in labour productivity from 2002 to 2008 into the contribution from investment (capital deepening), the contribution from intermediate input deepening, and multifactor productivity growth.[23] The contribution of capital deepening is estimated as the growth in capital per hours worked times the share of capital income in nominal gross output. The contribution of intermediate input deepening is estimated as the growth in intermediate input per hours worked times the share of intermediate inputs. The residual component is multifactor productivity growth, which captures the effect of changes in technologies and organizations that are not embodied in investment in medical equipment.

23. The data on gross output and intermediate input were available up to the year 2008.

**Table 6**
**Sources of labour productivity growth in the hospital sector, Canada, 2002 to 2008**

| | Annual growth |
|---|---|
| | percent |
| Labour productivity growth | 2.0 |
| Contribution of | |
| Capital deepening | 0.1 |
| Intermediate input deepening | 1.6 |
| Multifactor productivity growth | 0.3 |

**Note:** Authors' estimates.
**Sources:** Statistics Canada, Capital and Repair Expenditures Survey and Input-Output Accounts; and Canadian Institute for Health Information, Canadian MIS Database, Discharge Abstract Database, and National Ambulatory Care Reporting System.

Capital stock for the hospital sector is estimated from investment using the perpetual inventory method. The data on investment are from the annual Capital and Repair Expenditures Survey, which collects data on capital expenditures for all business and government entities. The data on intermediate inputs are from the Input-Output Accounts of Statistics Canada.

Labour productivity growth was largely due to intermediate input deepening, which includes expenditures on drugs. Multifactor productivity which provides a more comprehensive measure of the efficiency with which resources are used to produce output (patient services) increased 0.3% per year over the 2002-to-2008 period.[24]

# 5 Conclusion

This paper constructed an experimental volume index of hospital sector output by aggregating inpatient and outpatient cases using their cost share as weights. This cost-weighted activity index was corrected for substitution bias and aggregation bias. Substitution bias arises when a shift from inpatient to outpatient treatment occurs, and inpatient and outpatient cases are assigned to different case types and aggregated using their respective unit costs as weights. Aggregation bias arises when the index is constructed using a case-type classification at a high level of aggregation.

The analysis reveals a large substitution bias in the index when inpatient and outpatient cases are aggregated using their respective unit costs as weights. The substitution bias represents quality improvements stemming from shifts toward outpatient care that are not captured in the normal cost-weighted activity index.

The results of this study support the Organisation for Economic Co-operation and Development recommendation that inpatient and outpatient cases not be separated for estimating the cost-weighted activity index (Schreyer 2010). Rather, they should be grouped together if they make a similar contribution to health outcomes. However, this is not always feasible, because they are frequently assigned to different case types using different classification systems. In such instances, the cost-weighted activity index may seriously underestimate the volume index of hospital services when there has been a shift toward cheaper outpatient treatment that yields similar or improved health outcomes.

24. Because the capital income of the hospital sector in the National Accounts includes only the consumption of capital, not the returns on capital, the share of capital income and the contribution of capital deepening are underestimated.

The quality-adjusted estimate of the direct output measure of the hospital sector increased 4.3% per year over the 2002-to-2010 period. The price index of the output of the hospital sector increased 2.7% per year, slightly faster than the growth in the price index of gross domestic product. Labour productivity in the hospital sector based on the direct output measure is estimated to have increased 2.6% per year.

This paper focuses on quality changes in the hospital sector as a result of the trend toward outpatient treatment of diseases/conditions that formerly had been handled on an inpatient basis. The study does not address the effect of quality improvements within the same types of treatments on the volume index. Dawson et al. (2005) found evidence of quality improvement within the same type of treatments, but the effect was not nearly as large as that arising from the substitution of outpatient for inpatient treatment described in this paper.

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